Transpl Int (1995) 8: 407–410

BRIEF REPORT

François Durand
Jean Aschehoug
Alain Sauvanet
Jacques Bernuau
Jean-Pierre Benhamou
Serge Erlinger
Jacques Belghiti

Preservation of renal perfusion and postoperative renal function by side-to-side cavo-caval anastomosis in liver transplant recipients

Received: 11 February 1994
Received after revision: 13 March 1995
Accepted: 29 March 1995

F. Durand (✉) · J. Bernuau
J.-P. Benhamou · S. Erlinger
Service d'Hépatologie
et Unité INSERM U24,
Hôpital Beaujon,
100 Bd du Général Leclerc,
F-92118 Clichy, France
Fax: +33 1 4737 0533

J. Aschehoug · A. Sauvanet · J. Belghiti
Service de Chirurgie Digestive,
Hôpital Beaujon,
100 Bd du Général Leclerc,
F-92118 Clichy, France

Abstract Postoperative renal failure is common after liver transplantation (LT). The aim of this study was to investigate peroperative renal perfusion and postoperative renal function in 12 patients who underwent LT with side-to-side cavo-caval anastomosis (SSCCA). Three phases were considered during the procedure: hepatectomy, the anhepatic phase, and the postreperfusion phase (phases 1, 2, and 3, respectively). Mean arterial pressure, IVC pressure, and renal perfusion pressure were significantly higher during phase 2 than during phases 1 and 3. Cardiac index and pulmonary capillary wedge pressure did not differ significantly during the three phases. Creatinine clearance did not significantly decrease postoperatively. We conclude that SSCCA is associated with both the preservation of renal perfusion pressure during the entire procedure and the preservation of postoperative creatinine clearance. It is, moreover, a technique that results in a low rate of postoperative renal failure after LT.

Key words Liver transplantation, side-to-side caval anastomosis, renal function · Renal function, liver transplantation · Side-to-side caval anastomosis, liver transplantation, renal function · Cavo-caval anastomosis, liver transplantation, renal function

Introduction

Acute renal failure is a common complication in the early postoperative course of liver transplantation (LT). Compromised preoperative renal function, which is frequent in patients with cirrhosis, has been shown to be a major predisposing factor. The occurrence of acute renal failure restricts cyclosporin administration because of its renal toxicity and may sometimes require hemodialysis [3, 10]. In the standardized orthotopic liver transplantation technique, the retrohepatic inferior vena cava (IVC) is removed as part of the recipient hepatectomy. Thus, the IVC is totally clamped during the anhepatic phase. Decreased venous return, decreased cardiac output, increased IVC pressure, and decreased renal perfusion pressure associated with total IVC clamping may contribute to reducing renal perfusion during the anhepatic phase.

A new surgical technique, recently developed at our institution and consisting of full preservation of the recipient's IVC and side-to-side cavo-caval anastomosis (SSCCA) after partial IVC clamping, preserves IVC blood flow during the entire procedure [1]. The aim of this prospective study was to investigate peroperative renal perfusion and postoperative renal function in patients undergoing LT with SSCCA.

Patients and methods

Twelve consecutive patients (eight males and four females) who underwent LT between August 1991 and January 1992, were included in this study. Their mean age was 39 years (range 21–55 years). Indications for LT were: alcoholic cirrhosis ($n = 2$), hepatocellular carcinoma ($n = 2$), primary biliary cirrhosis ($n = 1$), primary sclerosing cholangitis ($n = 1$), congenital hepatic fibrosis ($n = 1$), Budd-Chiari syndrome ($n = 1$), cirrhosis of unknown ori-

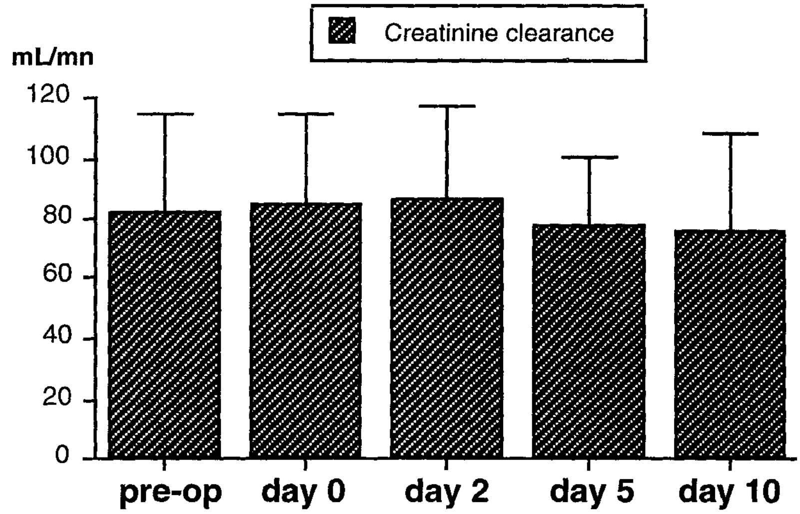

Fig. 1 Creatinine clearance values preoperatively and postoperatively at days 0, 2, 5, and 10

gin ($n = 1$), fulminant hepatitis B ($n = 1$), fulminant hepatitis of unknown origin ($n = 1$), and polycystic liver disease ($n = 1$). The latter patient underwent combined liver and kidney transplantation because of concomitant polycystic kidney disease. One patient died immediately after the procedure because of unexplained ventricular arrhythmia leading to cardiac arrest. Another patient died at day 16 because of pulmonary aspergillosis. The remaining ten patients are currently alive with a mean follow-up of 20.7 months.

All patients underwent orthotopic LT with SSCCA. The surgical technique of SSCCA has been described elsewhere [1]. In summary, hepatectomy is performed after retrohepatic vena cava dissection with control of the three major hepatic veins and the short hepatic veins. Thus, the IVC remains patent during hepatectomy and venovenous bypass is not necessary. After the recipient's liver is removed, a vascular clamp is placed laterally on the anterior part of IVC, preserving IVC blood flow during the anhepatic phase. A longitudinal cavotomy is performed in both the recipient and donor IVC. A side-to-side caval anastomosis is then performed. Once portal vein anastomosis is completed, blood flow is restored by removing caval and portal clamps.

The mean duration of LT was 11 h (range 6–15 h). Mean peroperative transfusions were 12.4 packed red cell units (range 0–33) and 26 fresh-frozen plasma units (range 12–40). During the procedure, a pulmonary artery catheter (7 Fr, Edwards Laboratories, Irvine, Calif. USA), a radial arterial line, and a femoral vein catheter were inserted in all patients. The extremity of the femoral vein catheter was placed at the level of the infrarenal portion of the IVC. Cardiac output was measured in triplicate and the result expressed as the mean value (Thermodilution method, 10 ml of room temperature dextrose, Hewlett Packard HP M1012A computer).

Three phases were considered during the transplantation procedure: hepatectomy (phase 1), the anhepatic phase (phase 2), and the postreperfusion phase (phase 3). During each phase, mean arterial pressure (MAP), IVC pressure (IVCP), and renal perfusion pressure (RPP = MAP–IVCP) were recorded every 5 min. Moreover, during each phase, cardiac index (CI), pulmonary capillary wedge pressure (PCWP), and systemic vascular resistance (SVR) were determined in stable condition. Creatinine clearance was calculated according to Cockroft and Gault's formula [4]. Creatinine clearance was calculated preoperatively, at the end of each operative phase, at day 0 (before cyclosporin administration), and at days 2, 5, and 10 (after cyclosporin administration in the seven patients who received this drug). The immunosuppressive regimen during the first 2 weeks post-transplantation included steroids, cyclosporin, and azathioprine in seven patients; steroids and azathioprine in four patients; and steroids, antithymocyte globulins, and azathioprine in one patient.

Informed consent was obtained from all the patients included in this study.

Results

All patients underwent peroperative hemodynamic assessment. However, one patient who died shortly after the procedure and one patient who underwent combined liver and kidney transplantation did not undergo creatinine clearance comparison.

The results of hemodynamic measurements during phases 1, 2, and 3 are listed in Table 1. A comparison of these measurements showed that the mean values of MAP and IVCP were significantly higher during phase 2 than during phases 1 and 3. The mean value of RPP was also significantly higher during phase 2 than during phases 1 and 3. In contrast, mean values of CI,

Table 1 Comparison of mean arterial pressure (MAP), inferior vena cava pressure (IVCP), renal perfusion pressure (RPP), cardiac index (CI) systemic vascular resistance (SVR), and pulmonary capillary wedge pressure (PCWP) during phases 1, 2, and 3

	Peroperative phases			
	1	2	3	*P*
MAP (mm Hg)[a]	85	94	82	< 0.001
IVCP (mm Hg)[a]	13	19	14	< 0.001
RPP (mm Hg)[a]	72	74	68	< 0.01
CI (dyne · sec^{-1} · cm^{-5})	5.4	4.3	5.9	NS
SVR (L · mn^{-1} · m^{2})	627	817	523	NS
PCWP (mm Hg)	10	9	11	NS

[a] Mean value

SVR, and PCWP were not significantly different during the three phases.

Creatinine clearance values determined in the ten patients who were considered for creatinine clearance comparison preoperatively and postoperatively at days 0, 2, 5, and 10 were 83, 76, 91, 110, and 95 ml · mn^{-1}, respectively (Fig. 1). Although creatinine clearance decreased slightly at day 0 postoperatively, these changes were not significant. The results of this comparison are illustrated in Table 1. Cyclosporin was never administered earlier than day 1 post-transplantation. In the seven patients who were given cyclosporin, the mean serum cyclosporin concentrations were 118, 272, and 405 ng/ml at days 2, 5, and 10, respectively (polyclonal assay).

Discussion

Acute renal failure is a common and severe complication of LT [3]. In two studies of patients undergoing LT with the classical technique, i.e., retrohepatic IVC resection with total IVC clamping, Taura et al. [12] and Shaw et al. [9] showed that CI is significantly decreased after total IVC clamping. In some patients, decreased cardiac output is associated with severe hypotension, and a rapid infusion technique fails to achieve hemodynamic stability. In such cases, several studies demonstrated that venovenous bypass could restore hemodynamic stability [9, 12]. Although venovenous bypass has been shown to be a safe alternative to restore cardiac output and MAP, its protective effects against postoperative renal failure in liver transplant recipients remain controversial [5, 8, 9, 12]. Furthermore, venovenous bypass, which increases surgical time, can be responsible for several complications, such as air embolism and thromboembolism [7].

After IVC clamping, Taura et al. [12] and Merrit et al. [8] also showed that the IVCP usually increased up to 30 mm Hg during the anhepatic phase and, consequently, that RPP decreased to below 60 mm Hg.

The results of these previously reported series show that decreased cardiac output and increased IVCP are two major factors of postoperative renal failure in patients undergoing LT with total IVC clamping. Both factors account for the reduction in renal perfusion pressure and renal blood flow.

On the basis of these findings, our purpose was to develop a surgical technique that could avoid the hemodynamic changes mentioned above. Surgical techniques consisting of full preservation of the recipient's IVC have been reported recently [2, 11, 13]. They are of particular interest when small liver grafts are used in larger recipients [2]. However, temporary total IVC clamping is required and, thus, the potential hemodynamic advantages of the SSCCA technique are not obtained.

What is original about the technique developed at our institution is that it avoids total IVC clamping and preserves IVC blood flow, at least in part, during the entire procedure. Thus, the main result with SSCCA was the preservation of peroperative renal perfusion and postoperative renal function.

The hemodynamic results of this technique are well illustrated in our patients since CI and MAP were not significantly decreased during the anhepatic phase. The same results have been observed by Jones et al. in a series of 19 patients undergoing LT with preservation of IVC blood flow [6]. It is important to note that none of our patients required either venovenous bypass or intensive vascular loading to obtain hemodynamic stability because none of them had a significant decrease in CI or MAP during the anhepatic phase. Thus, the PCWP remained within the normal range and the patients were not exposed to acute pulmonary edema after reperfusion.

In our patients, IVCP was not significantly increased, remaining below 20 mm Hg during the anhepatic phase. Thus, RPP did not significantly decrease, remaining above 60 mm Hg during the entire procedure. As a consequence of the preservation of RPP, creatinine clearance was not significantly increased postoperatively. Cyclosporin administration was found to be an important causative factor for early postoperative renal failure [5]. In our series, the preservation of postoperative renal function allowed the early introduction of cyclosporin without a significant decrease in creatinine clearance.

While the absence of a control group does not allow us to state definitely that SSCCA is superior to venovenous bypass for preserving peroperative renal perfusion, our results do indicate that partial clamping of the IVC, associated with SSCCA, is a safe and effective procedure that results in a low rate of early postoperative renal failure in liver transplant recipients.

References

1. Belghiti J, Panis Y, Sauvanet A, Gayet B, Fekete F (1992) A new technique of caval anastomosis during orthotopic liver transplantation without inferior vena cava occlusion. Surg Gynecol Obstet 175: 270–272
2. Bismuth H, Castaing D, Sherlock D (1990) Liver transplantation by "face-à-face" venacavaplasty. Surgery 111: 151–155
3. Carithers RL, Fairman RP, Mendez-Picon G, et al (1988) Post operative care. In: Maddrey WC (ed) Transplantation of the liver. Current topics in gastroenterology. Elsevier, New York, p 134

4. Cockroft DW, Gault MH (1976) Prediction of creatinine clearance from serum creatinine. Nephron 16: 31–41
5. Gunning TC, Brown MR, Swygert TH, et al (1991) Perioperative renal function in patients undergoing orthotopic liver transplantation. Transplantation 51: 422–427
6. Jones R, Hardy KJ, Fletcher DR, Michell I, McNicol PL, Angus PW (1992) Preservation of the inferior vena cava in orthotopic liver transplantation with selective use of venovenous bypass: the piggy back operation. Transplant Proc 24: 189–191
7. Kelley SD (1992) Venovenous bypass during liver transplantation. Anesth Analg 75: 481–483
8. Merritt WT, Beattie C, Peck R, Burdick JF, Klein AS, Dickstein R (1990) Vena caval pressure gradients during liver transplantation. Transplantation 50: 336–338
9. Shaw BW, Martin DJ, Marquez JM, et al (1984) Venous bypass in clinical liver transplantation. Ann Surg 200: 524–534
10. Shaw BW, Stratta RJ, Donovan JP, Langnas AN, Wood RP, Markin RJ (1989) Postoperative care after liver transplantation. Semin Liver Dis 9: 202–230
11. Stieber AC, Marsh JW, Starzl TE (1989) Preservation of the retrohepatic vena cava during recipient hepatectomy for orthotopic transplantation of the liver. Surg Gynecol Obstet 168: 543–544
12. Taura P, Beltran J, Garcia-Valdecasas JC, et al (1991) The need for venovenous bypass in orthotopic liver transplantation. Transplantation 52: 730–733
13. Tzakis A, Todo S, Starzl T (1989) Orthotopic liver transplantation with preservation of the inferior vena cava. Ann Surg 210: 649–652